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MINNESOTA UNIV MINNEAPOLIS DEPT OF PHYSIOLOGY  
DYNAMIC CHARACTERISTICS OF HUMAN MOTOR PERFORMANCE IN CONTROL S--ETC(U)  
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19. ABSTRACT (Continue on reverse side if necessary and identify by block number) The main point of the project is to study the relation between the parameters of movement and the motor output patterns to the working muscles in order to obtain information about the underlying control system. Several lines of investigation have been used in addition to input-output studies with human subjects. The input, largely comprising information from muscle receptors, has been further illustrated by specific studies of muscle spindle receptors and nerve membrane properties. The central organization has been studied in various animal experiments in various motor control problems including the neural control of		

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respiration and vestibular organization. In addition, computer simulations of small neuronal networks have added an understanding of circuits involved in motor performance.

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DYNAMIC CHARACTERISTICS OF HUMAN MOTOR PERFORMANCE IN CONTROL SYSTEMS

AFOSR-TR-80-0760

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FINAL REPORT

(Sept. 1975 - Nov 1979)

In the period covered by this report, September, 1975 through November, 1979, the computer facilities made available to the Laboratory of Neurophysiology by the above referenced grant have been an essential part of the research and teaching activities of the staff and pre- and post-doctoral Fellows. The research projects conducted during this period were on the following principal topics:

1. Motor control and perceptual-motor organization
2. Receptor properties
3. Membrane properties of neurons
4. Organization of the central control of respiration
5. Data processing by small neuronal networks.

The results of these investigations have been published or are in the process of being published; a complete list is provided in Appendix I. A brief summary description of the principal results in each of the research areas follows.

1. Motor control and perceptual-motor organization.

The research projects in this area include studies of reflex control of movement and position in the human and in trained animals. The studies involve determinations of the relationship between isometric tension and EMG activity in man as well as the visco-elastic properties of human muscle; the relationship between vestibular inputs and muscle activity in awake cats; the unit activity in cerebellar nuclei and red nucleus during ongoing movements in trained animals; a mathematical description of the reflex mechanisms leading to correction for load disturbances and during tracking movements; the logic whereby motor patterns are represented in the nervous system. Findings include a detailing of linear and non-linear features of motor activity in biceps and triceps muscles of man as well as time variations in reflex gain and reflex dynamics during intentionally controlled movements, and the identification of a general principle, valid for both learned and spontaneously initiated movements, that relates the trajectory to the speed of motion through a constant.



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## 2. Receptor Properties.

The research in this area has dealt with the biophysical properties underlying the behavior of mechanoreceptors and has focused on the behavior of the mammalian muscle spindle to provide more precise descriptions of its behavior in the motor control problem. Contributions made by the passive mechanical properties of intrafusal muscle as well as the role of fusimotor activation in determination of the spindle response to stretch have been determined. The non-linear dependence of muscle spindle response on the velocity and amplitude of muscle stretch and the way in which this behavior is influenced by motor commands were described and analyzed.

## 3. Membrane Properties of Neurons.

This research has focused on two areas that are involved in the encoding of information by nerve cells. One was directed to an increased understanding of the mechanisms and properties of repetitive firing in sensory neurons, and the other to an analysis of specific membrane mechanisms responsible for potassium conductance. Tonic repetitive firing has been modeled for the first time for a normal, non-space-clamped membrane. Non-uniformities of membrane excitation properties were taken into account and results show a marked lowering of and linearization of the impulse frequency with stimulus intensity. The role of the electrogenic pumping of ions across the membrane in the encoding process was delineated in detail and the excitation parameters of the impulse trigger zone were derived from a statistical evaluation of impulse trains using a systems analysis approach.

Voltage clamp studies in squid axon and extensive computer modeling are helping to illuminate the role of diffusion and potential energy profiles in the nerve membrane in the determination of electrical conductance across the membrane.

## 4. Organization of the Central Control of Respiration.

The role of the medullary-pontine interactions in the control of respiration has been studied using anatomical tracing, designed to locate the pathways and nuclei involved, and electrophysiological techniques designed to determine patterns of neuronal discharge of the various elements in the pathways. Together these studies have revealed a previously

unreported substructure of the medulla wherein neurons are organized in thin sheets which run longitudinally within the brainstem.

Microelectrode recordings were made from neurons in the brainstem of the cat in regions thought to be involved in generating the respiratory rhythm. Results are consistent with the hypothesis that respiration is controlled at the bulbopontine level by the time course of activity in a pool of central inspiratory inhibitory neurons whose activity is greatest early in expiration, then gradually decays during expiration to a level at which inspiratory neurons are released.

##### 5. Data Processing by Small Neural Networks.

These studies included both the development of a program for the IBM 1800 for the stimulation of small neuronal networks and experimental studies that were analyzed by means of the simulations. System identification techniques that rely on noise signals as input were used to determine input-output relationships in the neurons of Clarke's column of the spinal cord. Results show that extracellular recording of impulse activity could be used to deduce excitatory and inhibitory interactions intracellularly and it revealed an extensive convergence of sensory input as well as descending influences from the brain stem reticular formation. Patterns of neuronal discharge from brain-stem neurons thought to be involved in generating respiratory rhythms were correlated with different phases of the respiratory cycle. Spike activities of two simultaneously recorded neurons were cross-correlated to detect possible synaptic interactions. Simulations of known neural interactions were used to interpret resulting patterns.

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APPENDIX I. Publications from the Laboratory of Neurophysiology 1975-1980

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## APPENDIX II. Laboratory Staff

R.E. Poppele, Professor and Director

C.A. Terzuolo, Hill Professor

R.L. Purple, Professor

C.K. Knox, Associate Professor

J.F. Soechting, Associate Professor

J.F. Fohlmeister, Assistant Professor

Fellows:	Degree <u>Awarded</u>	Date <u>Date</u>
John Anderson	M.D., Ph.D.	1973, 1976
Joel Dufresne	Ph.D.	1977
Gary King	Ph.D.	1979
Stephen Dawis	Ph.D.	1980
Fay Horak	M.S.	1977
Sofia Robles	M.S.	1978
Stephen Holloway	M.S.	1976
Deborah MacNeill	--	--
Michael Anderson	M.D.	1979

Paulo Viviani, Visiting Fellow

Constantinos Pappas, Visiting Fellow

